Title:

The Bath University Rugby Shuttle Test (BURST): a pilot study

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Abstract

Purpose. This study presents an exercise protocol utilising movement patterns specific to rugby union forwards and assesses the reproducibility of scores from this test. **Methods.** After habituation, 8 participants (mean ± *s*: age = 21 ± 3 years, height = 180 ± 4 cm, body mass = 83.9 ± 3.9 kg) performed the Bath University Rugby Shuttle Test (BURST) on two occasions, one week apart. The protocol comprised 16 x 315-s cycles (4 x 21-min blocks) of 20-m shuttles of walking and cruising with 10-m jogs, with simulated scrummaging, rucking or mauling exercises and standing rests. In the last minute of every 315-s cycle, a timed Performance Test was carried out, involving carrying a tackle bag and an agility sprint with a ball, followed by a 25-s recovery and a 15-m sprint. **Results.** Participants travelled 7078 m, spending 79.8 and 20.2% of time in low and high-intensity activity, respectively. The coefficients of variation (CV) between trials 1 and 2 for mean time on the Performance Test (17.78 ± 0.71 *vs* 17.58 ± 0.79 s) and 15-m sprint (2.69 ± 0.15 *vs* 2.69 ± 0.15 s) were 1.3 and 0.9%, respectively. There was a CV of 2.2% between trials 1 and 2 for mean heart rate (160 ± 5 *vs* 158 ± 5 beats.min^{-1}) and 14.4% for blood lactate (4.41 ± 1.22 *vs* 4.68 ± 1.68 mmol.l^{-1}). **Conclusion.** Results suggest that measures of rugby union-specific high-intensity exercise performed during the BURST were reproducible over two trials in habituated participants.

Key words

Rugby union, intermittent, high intensity, performance

Introduction

Match play in rugby union is characterised by periods of intermittent submaximal activity interspersed with short bouts of high-intensity activity.[1-3] These aspects of match play have been quantified using notational and time-motion analysis methods.[1-3,11] However, detecting and quantifying the effect of interventions on performance in match play is challenging given the variability in performance between matches due to tactical and environmental factors[4].

Due to the complexity and lack of control inherent in match play, exercise protocols based on time-motion analysis have been devised to replicate the demands of team sports in a controlled environment. Soccer simulation protocols have been designed for treadmill running,[5,6] indoor shuttle running[7] and outdoor shuttle running,[8] and although these tests are valid replications of the demands of soccer match play, such protocols cannot be transferred to rugby union due to the specific demands of the two sports. The difference is particularly highlighted by the presence of contact activities such as scrums, rucks, mauls and tackles in rugby union which are not present in soccer or many other team sports. One study has used a protocol to simulate the demands of rugby union[9] but information regarding how well the protocol compared to match play and the reproducibility of performance and physiological responses over repeated trials were not reported. The aims of this pilot study are twofold: firstly to present a novel test of high-intensity exercise capabilities that involves movement and activity patterns specific to rugby union forwards; and secondly to assess the reproducibility of performance and physiological measures from the tests over two trials in habituated participants.

Methods

Participants

Eight men (mean ± *s*: age = 21 ± 3 years, height = 180 ± 4 cm, body mass = 83.9 ± 3.9 kg, years playing experience = 12 ± 3) volunteered to take part in this study. All played University-standard rugby union and were involved in match play and training throughout the study. Participants were provided with verbal and written information on the requirements of the study before providing written informed consent. Approval for the study was granted by the University of Bath's School for Health Research Ethics Approval Panel within the guidelines of the Declaration of Helsinki.

Preliminary visits

Prior to the first main trial, participants attended two habituation sessions one week apart. In both sessions, participants carried out the Performance Test (described below) three times with 5 min rest between each followed by 30 min of the Bath University Rugby Shuttle Test (BURST; described below) to become accustomed to the exercise patterns.

Experimental design

Participants completed the BURST on two occasions approximately seven days (range 6-8 days) apart, with the first main trial one week after the second habituation session. Participants recorded their diet for 48 hours prior to the first trial and were instructed to replicate this prior to the second trial. They were also asked to refrain from strenuous activity for 24 hours prior to each trial. On the morning of a trial, participants were asked to consume 500 ml of water after waking to ensure euhydration. After arriving in the laboratory following a 10-hour overnight fast, participants ingested a further 500 ml of water. Body mass was recorded to the nearest 50 g using a beam balance scale (Avery Berkel, UK) with the participant wearing only underwear. One hour after arrival in the laboratory, the participants began the BURST protocol. Fingerprick capillary blood samples (300 µl) were collected in an EDTA blood collection tube (Microvette 500 EDTA, Sarstedt, Germany) 30 s into rest periods after blocks 1, 2, 3 and 4 of the protocol, followed by the ingestion of 4 $ml.kg^{-1}$ of water. Capillary whole blood was analysed for lactate and glucose using an automated analysis method (YSI 2300 Stat Plus, Yellow Springs Instruments, California, USA). Mean heart rate (Polar Vantage NV, Polar Electro, Finland) was recorded for every 315-s period. Ratings of Perceived Exertion (RPE)[10] were recorded at the end of each 315-s period. After the BURST, participants towelled themselves down to remove sweat and body mass was recorded. Experimenters made every effort to provide the same level of verbal encouragement to the participants throughout all trials.

Bath University Rugby Shuttle Test (BURST)

The physical demands for the protocol were derived from those described for elite level rugby union match play for forwards.[11] Participants began with a 10-min warm-up, comprising 5 min of jogging and stretching, followed by one 5-min period of the BURST excluding the Performance Test. After a 2-min recovery, a Performance Test and 15-m sprint (Baseline test) were performed immediately prior to the onset of the first exercise block in order to provide a maximal baseline measure of performance. The BURST comprised 16 x 315-s exercise periods grouped into 4 x 21-min blocks (Figure 1). Blocks 1 and 3 were followed by 4-min breaks, with 2 min allocated each to standing and walking. These 4-min breaks were included as part of the exercise protocol when determining proportions of time spent standing and walking, thus increasing the exercise time to 92 min in line with a total match duration previously determined for English Premiership rugby.[3] A 10-min ‘half time’ break followed block 2, comprising 7 and 3 min of sitting and walking, respectively.

The exercise was performed in a 20-m lane on an indoor athletics track. An exercise cycle required the participants to walk 20 m, turn 180° and cruise 20 m, turn 180° and jog 10 m, then perform either a scrum [a 1.5-m drive of a single person scrummaging machine (120 kg Rhino, London, UK) in 7 s], ruck [5-m drive of a 20-kg tackle bag (Gilbert, UK; dimensions: 140 cm height, 40 cm diameter) in 3.5 s, on which shoulder contact was made at a marked point on the bag to standardise body position] or maul [participants competed alternately against another person for 5 s to either maintain (starting with the ball) or to gain possession (starting without the ball)]. They then jogged backwards 10 m and repeated the cycle following a standing rest. A 315-s period included five exercise cycles with scrums in cycles 1 and 3, rucks in cycles 2 and 4, a maul in cycle 5 and a Performance Test and 15-m sprint (Figure 2). The participant was reminded of which activity to perform throughout by spoken commands and timing was maintained by computer generated signals from a specifically recorded CD. Walking, jogging and cruising were performed at mean speeds of 1.4, 3.0 and 4.2 $m.s^{-1}$, respectively, based on the median values of the same activity categories from time-motion analysis.[11]

Insert Figure 1 here

Performance Test (Figure 2)

Following the maul, the participant walked to the start of the Performance Test and waited for the instruction to begin. From a standing start 0.5 m behind timing gate 1 (Smartspeed, Fusion Sport, Australia), the participant passed through the gate, picked up the closest tackle bag driving it 9 m, and placed over a line before sprinting back to the second tackle bag, again driving it 9 m and placing it over the line. They then sprinted back 9 m, picked up the ball and carrying it in one hand, sprinted through gate 2 which triggered either gate 3 or 4 to flash continuously. The participant then continued to sprint through two upright poles, then making a sudden change of direction to sprint through the gate which was flashing. Prior to passing through gate 2, the participant did not know whether they would have to change direction towards gate 3 or 4. The time from passing through gate 1 to gate 3/4 was recorded (Performance Test time). The participant then had 25 s to return to gate 1, and then from a standing start, performed a single 15-m sprint between gates 1 and 2 (15-m Sprint time). Apart from the 25 s of recovery, the Performance Test and 15-m sprint were performed with maximum effort.

Insert Figure 2 here

Statistical Analysis

All data are presented as mean ± *s*. All values for performance measures are presented as the mean in each 21-min block. Baseline times for the Performance Test and 15-m sprint are presented independently to the means of those performed during the BURST. Agreement between mean Performance Tests, 15-m sprint, heart rate, RPE and blood lactate and glucose in the two experimental trials are expressed as the typical error of measurement (TEM) expressed in absolute units and as the mean percentage TEM, referred to as coefficient of variation (CV) with 90% confidence limits derived from log-transformed raw data using methods described by Hopkins.[12] Fatigue index is calculated as the percentage change in performance from the baseline measure to the mean of exercise in block 4 for the Performance Test and 15-m sprints.

Results

Exercise protocol movement demands

The movement demands of the BURST are described in Table 1, alongside corresponding values from the time-motion analysis from which the BURST demands were derived. Static exertion combines scrummaging, rucking and mauling and High-intensity activity includes static exertion, cruising and sprinting. Low-intensity activity includes standing, walking and jogging.

Insert Table 1 here

Reliability

Typical error of measurement, expressed in absolute units and as a percentage (coefficient of variation) for performance and physiological measures are shown in Table 2. The fatigue index for trials 1 and 2 were 9.7 ± 4.1% and 9.1 ± 3.3%, respectively for the Performance Test and 4.4 ± 5.8% and 4.4 ± 6.5% for the 15-m sprint. The highest measured values for blood lactate were observed after 21 min of exercise for both trials 1 (4.89 ± 1.48 $mmol.l^{-1}$) and 2 (5.06 ± 1.66 $mmol.l^{-1}$).

Insert Table 2 here

Discussion

This study presents a shuttle running protocol which comprises movement and activity patterns specific to rugby union forwards. The low coefficients of variation indicate that both performance measures and heart rate are reproducible over repeated trials in habituated participants.

The small change in the baseline and mean times for the Performance Tests and 15-m sprints between trials 1 and 2, suggest that there was not a large learning effect in trial 2. However, Performance Test and 15-m sprint times were not recorded during the two habituation sessions and therefore it is uncertain as to whether learning effects were minimised prior to the main trials. The variability around the mean (*s*) is greater for the mean Performance Test time than for the baseline, indicating more variation in individual performance after starting the BURST compared to pre-exercise. This larger between-subject variation at the end of exercise is further demonstrated when the mean ± *s* Performance Test time is compared between baseline (combined time for trials 1 and 2: 16.35 ± 0.34) and after 92 min of exercise (17.66 ± 0.90).

The percentage coefficient of variation for the time taken to complete the baseline Performance Test was 1.1% between trials 1 and 2 with a corresponding value of 1.3% for the mean time to complete Performance Tests during the BURST. This low typical error between trials 1 and 2 (Table 2) may be attributed to design features which optimised internal validity such as the Performance Test being straightforward to perform in terms of technique, activity order and the inclusion of activities to which the rugby playing participants were accustomed. Furthermore, technique was refined during habituation sessions. The %CV of 0.9% for the 15-m sprint is comparable to the smallest worthwhile effect of 0.8% determined previously for a 20-m sprint[16], the CV of 2.0% reported by Oliver *et al*.[15] for mean sprint time over 10 m and 2.3% over repeated trials of 10 x 20-m sprints.[16] Overall, while it is difficult to provide a definitive value for a smallest worthwhile change in performance, it can be considered that the low %CV values for the Performance Test (1.3%) and 15-m sprint (0.9%) reflect adequate reliability to allow detection of relatively small signals arising from a given intervention.

The total distance of 7078 m travelled in 92 min by participants in the BURST protocol is greater than the distance of 6418 m (extrapolated from 5581 m over 80 min) travelled by forwards in the study of Roberts *et al*.[11] from which the BURST demands were derived. This is attributable to greater distances travelled while cruising and sprinting compared to match play[11] and accounts for the greater amount of time spent in high-intensity activity in the BURST (20.3%) which is greater than the value of 16%[11] in the time-motion analyses of match play. Essentially, this is due to the fact that the BURST was designed to represent demanding match play, and is further warranted by the finding of Roberts *et al*.[11], that more than a quarter of the forwards analysed travelled more than 6200 m over 80 min (equivalent to more than 7100 in 92 min) of match play. In the BURST, each sprint reflects the distance over which the participant was instructed to sprint but during this time they would have been accelerating and therefore not achieving the speed (6.7 $m.s^{-1}$) defined as sprinting in the time-motion analysis. Therefore, an individual sprint in the BURST would represent a number of activities as the participant accelerated from standing to sprinting if analysed using the time-motion analysis method applied to match play.[11] On the same basis, the total number of discrete locomotive movements was greater for the time-motion analysis than the BURST; in the time-motion analysis a new activity bout was recorded every time a player moved into and out of a speed category as a result of accelerating or decelerating.

The 9.9% of time spent in static exertion during the BURST was the same as that determined for match play.[1,2,11] Participants completed 32 scrums compared with a range of 21[11] to 38[1] in time-motion analyses but performed a total of 80 rucks/mauls compared with previous time-motion analyses which have reported 67,[1] 49[3] and 60.[11] Tackles were not included in the BURST but it was considered that this activity would be compensated for with more rucks, particularly because a simulated tackle would have been a similar type of activity and forwards normally carry out 14 tackles during a match.[11] Static exertion bouts during the BURST were controlled to minimise injury, therefore collisions were less vigorous compared with match play. However, all bouts were carried out at high-intensity, particularly the maul, in which participants were instructed to perform with maximal effort. The Performance Test was longer in duration than any of the performance measures used in a previous rugby match simulation[9] and other team sport match simulations.[7,13] Given that the mean maximal duration for a match play high-intensity activity period has been reported to be 22 s[1] and 21 s[11] with a number of high-intensity bouts lasting more than 12 s,[2] the Performance Test was designed to simulate a prolonged high-intensity bout which can occur during a match. Furthermore, a sprint of 15 m replicates the mean discrete sprint distance identified by other time-motion analyses of rugby union forwards.[3,14]

The mean heart rate values for trials 1 and 2 returned a CV of 2.2%. Doutreloux *et al*.[17] reported that the mean heart rate for forwards was 180 beats·min^{-1} during match play while Deutsch *et al*.[14] showed that under-19 age group forwards spent at least 72% of match time with a heart rate greater than 85% of their maximum. Compared with a controlled laboratory test, heart rate during a rugby match may be greater for the same given work load due to factors such as elevated sympathetic nerve activity and catecholamine concentrations prior to competition.[18] For blood lactate concentrations, the CV of 14.4% was less than the CV of 17.6% following a repeated non-motorised treadmill protocol[19] and within the 15% range considered to be acceptable for reproducible blood lactate testing.[20] Mean blood lactate in the current study of 4.5 $mmol.l^{-1}$ was lower than the 6.6 $mmol.l^{-1}$ reported for under-19 match play[14] and international props (6.4 $mmol.l^{-1}$) and No. 8's, (6.7 $mmol.l^{-1}$).[21] However, such comparisons must be made cautiously because although sampling time points were controlled in the current study, these will be less structured during match play due to limited access to players, meaning that variations in the preceding intensity of activity will affect the blood lactate concentration.[22]

Indoor running was preferred compared to an outdoor, field-based setting on the basis of the controlled environmental conditions, despite the lower ecological validity. While the current study has sought to replicate the physical demands for rugby union forwards match play, there are limitations of doing so when using a controlled exercise model. For example, by using a limited amount of floor space for the 20-m shuttles, the BURST becomes more transferable to different locations but does require participants to perform 180° turns which might not fully reflect the changes in direction that occur during match play. Given that the validity of the BURST is currently inconclusive, future work could be undertaken to determine whether the current protocol can discriminate between players of differing playing abilities. In addition, validation testing may also incorporate the comparison of physiological measures between the BURST and rugby union forwards match play.

Practical applications

The BURST does not require a large space and only a few items of specialised equipment, (some of which may be replaced with more readily available alternatives) making it accessible to researchers seeking a rugby union forwards specific exercise protocol. For such a use, it is important that participants attend habituation sessions and that contact situations are controlled.

Conclusion

The current study is the first to present a rugby union specific exercise protocol (BURST) reflecting the demands of English senior elite level match play. Based on low coefficients of variation the BURST can be considered a reproducible exercise protocol in terms of performance measure indices and heart rate, which could be useful for tracking training-induced changes in aspects of rugby-specific fitness. Further work should examine the validity of physiological responses during the BURST in relation to match performance and its ability its ability to discriminate between players of different abilities.

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Tables

Table 1. The percentage of total time spent in each activity category and the number and mean duration (s) of selected activities during the BURST and Time-motion analysis[11].

Activity	Distance (m)		% Time		Mean duration (s)		Number	
	BURST	Time-motion	BURST	Time-motion	BURST	Time-motion	BURST	Time-motion
Standing	-	403 ± 75	31.2	32.5 ± 7.2	6.6	3.5 ± 0.6	224	592 ± 41
Walking	2800	2217 ± 387	33.5	35 ± 4.3	12.4	2.5 ± 0.2	128	871 ± 60
Jogging	1728	2328 ± 418	15.1	17.0 ± 3.1	5.7	2.0 ± 0.1	144	468 ± 87
Cruising	1888	1277 ± 320	8.1	5.2 ± 1.1	3.9	1.4 ± 0.2	112	192 ± 48
Sprinting	662	189 ± 213	2.2	0.4 ± 0.5	1.9	1.2 ± 0.3	64	18 ± 18
Scrummaging	-	-	4.1	3.2 ± 1.8	7.0	7.3 ± 1.1	32	24 ± 14
Rucking	-	-	4.4	2.5 ± 0.7	3.5	4.2 ± 0.6	64	40 ± 10
Mauling	-	-	1.4	3.5 ± 1.5	5.0	6.7 ± 1.4	16	29 ± 9
Total	7078	6418 ± 862	100.0	100.0	-	-	784	2234 ± 187
Static exertion	-	-	9.9	9.9 ± 2.4	4.9	5.2 ± 0.8	112	102 ± 24
Low-intensity activity	-	-	79.8	84.5 ± 1.8	19.1	22.6 ± 4.2	192	151 ± 42
High-intensity activity	-	-	20.2	15.5 ± 1.8	4.1	4.1 ± 0.8	192	151 ± 42

Table 2. Mean values of measures taken during the BURST (mean ± *s*), change in the mean, Typical Error of measurement (TEM) expressed in absolute terms and as percentage coefficient of variation (CV) (90% confidence limits) for performance and physiological parameters.

	Trial 1	Trial 2	TEM (Absolute) (90% confidence limits)	CV (%) (90% confidence limits)
Baseline Performance Test (s)	16.41 ± 0.36	16.29 ± 0.33	0.17 (0.12-0.31)	1.1 (0.8-1.9)
Mean Performance Test (s)	17.78 ± 0.71	17.58 ± 0.79	0.22 (0.16-0.40)	1.3 (0.9-2.3)
Baseline 15-m sprint (s)	2.58 ± 0.15	2.57 ± 0.12	0.10 (0.07-0.18)	3.9 (2.7-7.0)
Mean 15-m sprint (s)	2.69 ± 0.15	2.69 ± 0.15	0.02 (0.02-0.04)	0.9 (0.6-1.6)
Heart rate (beats.min^{-1})	160 ± 5	158 ± 5	3.59 (2.48-6.87)	2.2 (1.5-4.3)
RPE (6-20)	15 ± 1	15 ± 1	0.25 (0.18-0.45)	1.6 (1.1-2.8)
Blood Lactate (mmol.l^{-1})	4.41 ± 1.22	4.68 ± 1.68	0.70 (0.49-1.25)	14.4 (9.9-27.3)
Blood Glucose (mmol.l^{-1})	5.32 ± 0.78	5.34 ± 0.74	0.26 (0.18-0.47)	5.0 (3.5-9.1)
Change in Body mass (kg)	1.2 ± 0.3	1.1 ± 0.1	0.14 (0.10-0.26)	12.4 (8.6-23.5)

Figures

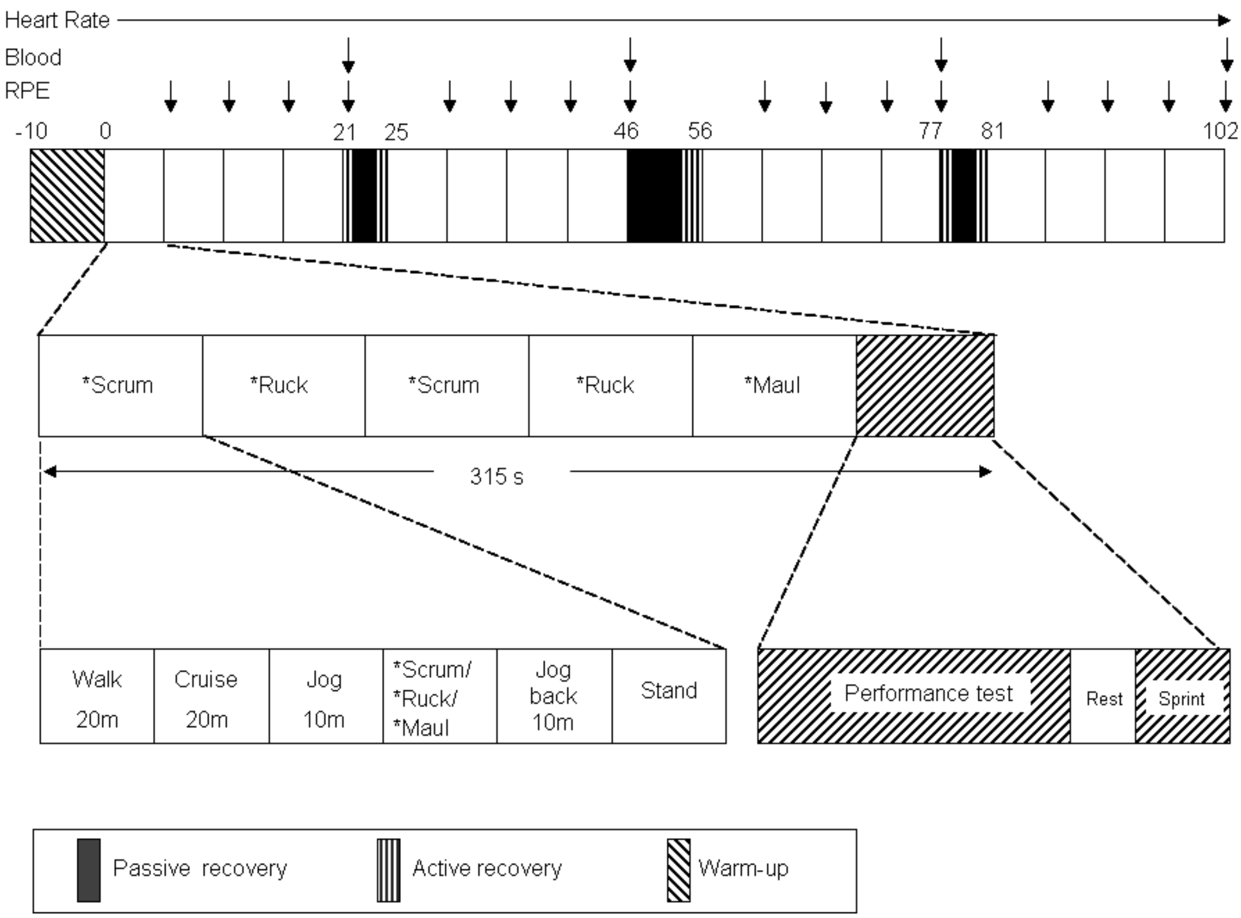

Figure 1. A schematic representation of the exercise patterns in the Bath University Rugby Shuttle Test (BURST).

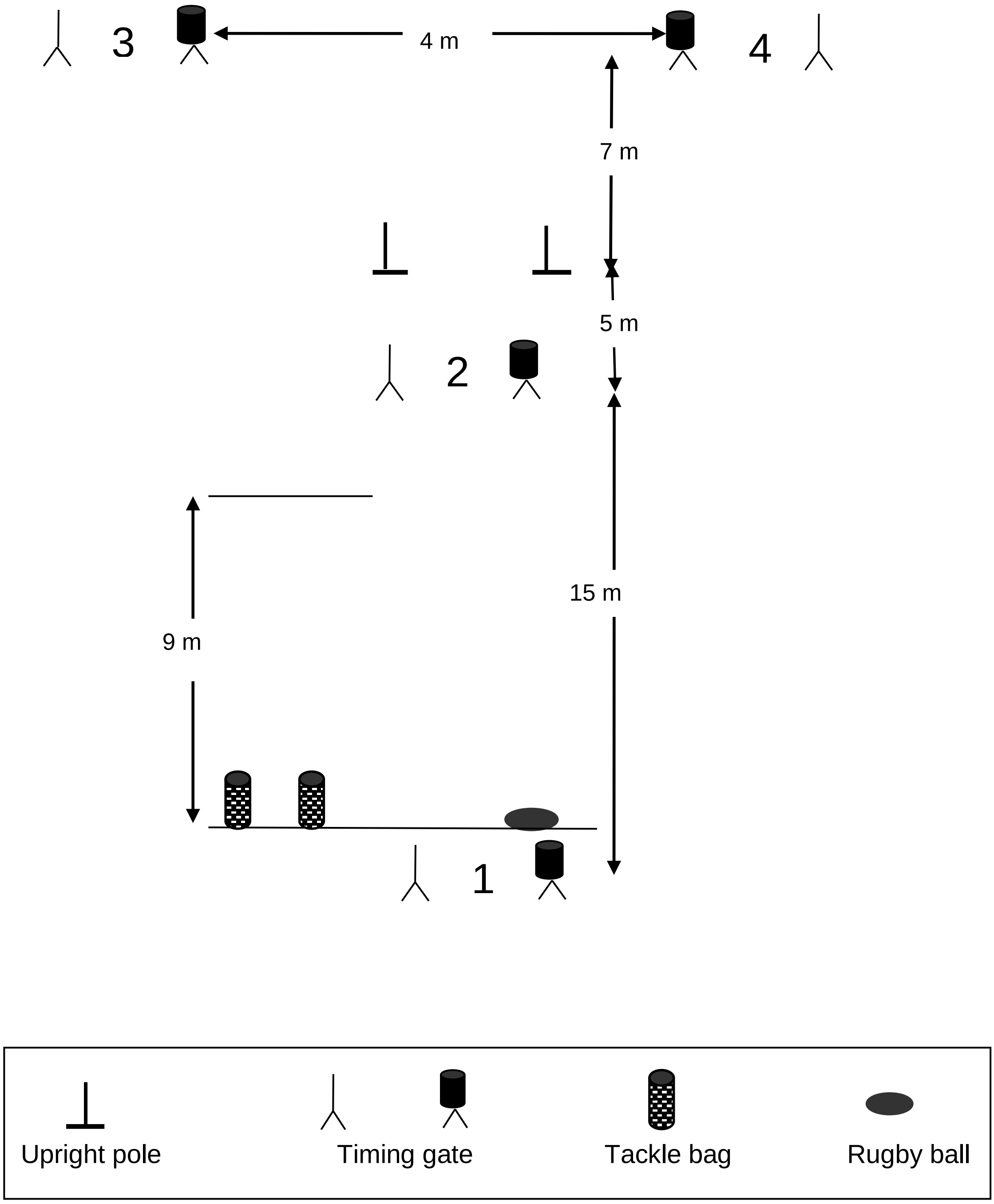

Figure 2. A schematic representation of the Performance Test area (not to scale).